WITH THE COMPLIMENTS OF
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ROTATORS OF THE FEMUR AND THEIR OTHER FUNCTIONS.*

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of Philadelphia.

THE modes of determining the function of muscles are probably confined to two methods of investigation; the one physiologic, the other mechanical. The physiologic method is that by which are noted the results following the application of a stimulus to the nerve supplying the muscle under study, and the mechanical that by which are observed the effects of the application of mechanical force to the muscle, or to a substitute for the muscle, acting under the same conditions as the muscle.

The physiologic method is limited in its application to the recent subject, and is open to doubt owing to the want of positiveness as to whether the supply-nerve is a single nerve, as it is supposed to be, or an unknown combination of nerves conveying impulses to we know not where.

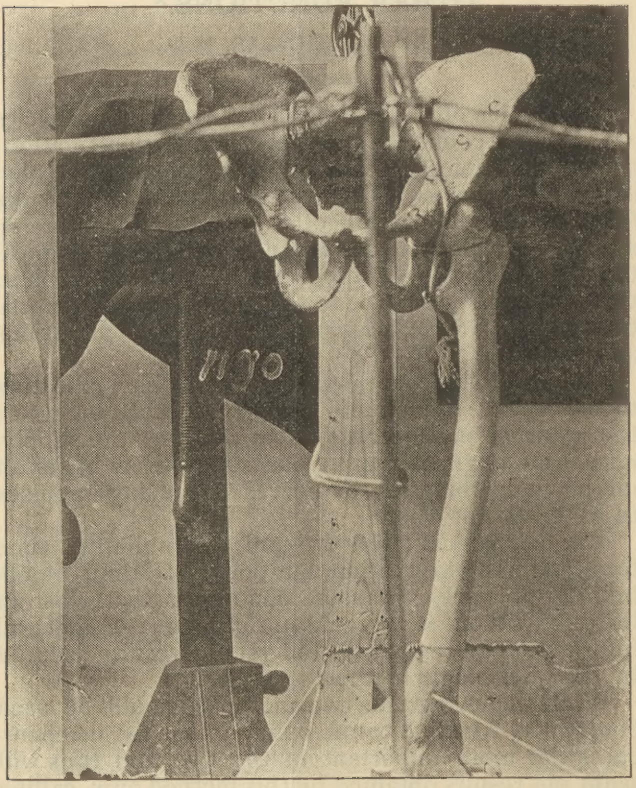
The mechanical method permits of unlimited time for study and observation, but does not admit of obtaining precisely the same conditions that exist in life; yet without it we could not gain the fundamental information necessary to understand results secured by the physiologic method.

While believing the two methods should be used conjointly, I incline to the opinion that the mechanical is the more important of the two, and thus will point out results obtained by this method only, calling attention, however, to errors that may lessen the value of the results. The intention is not to support a special system of investigation, but to present the results of investigation by that system.

* The essay winning the First Prize in the Department of Surgery, etc., of the PHILADELPHIA MEDICAL JOURNAL Prize-Contest, January 1, 1899.

The meat of this paper lies in the accompanying 13 rough drawings, showing diagrammatically the functions of all the rotators of the hip having insertions in the femur.

With the drawings is a crude model from which the drawings were made and upon which rotation and



PHOTOGRAPH 1170 represents the action of the psoas muscle when the femur is hanging vertically. The head of femur would be thrown out of the acetabulum if it was not tied fast as shown. The pointer in lower part of femur shows the position is one of external rotation, but to produce this result the rubber cord must lie in the depression between the pelvis and the head of femur. In life this space would be largely, if not entirely, filled up by the capsular ligament and other tissues; so the strong probability is that the psoas muscle could not rotate externally with the femur hanging vertically. See drawing No. 1184.

some other functions, shown by the drawings, can be demonstrated. A degree of accuracy so great as to show no variation between drawings and model would entail an expense not warranted by the competition invited; yet I think it will be found that except in two or three instances the differences are of degree and not of kind.

DESCRIPTION OF MODEL.

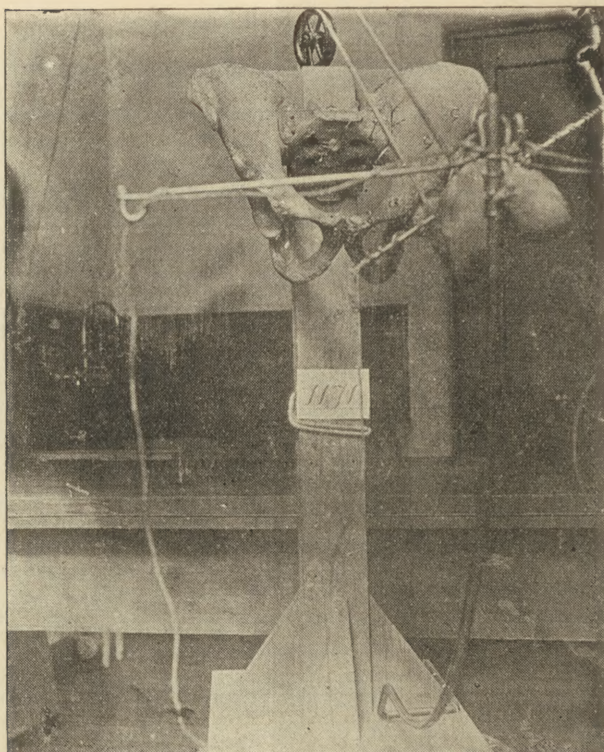
The model shown in photographs 1170, 1171, and 1172 consists of:

1. A wooden base and upright upon which is mounted a pelvis in the erect position.
   a. A pulley in top of upright over which a rubber cord (to be subsequently described) must run.
   b. Screw-hooks upon rear aspect of upright, in one of which the ring in end of rubber cord must be placed.
   c. Screw-hooks in pelvis, through which rubber cord must pass. These hooks represent origins or functional origins of muscles described on drawings and in paper.
2. A femur, the head of which is held in the acetabulum of pelvis by the elasticity of the rubber cord previously mentioned. This rubber cord is not used in any way as a binder to retain the head of the femur in the acetabulum, but does so by simply occupying the position and relations and performing the functions of the muscle to be demonstrated. In some positions and with some muscles the fingers will have to be used to prevent displacement of the head of femur.
   a. A straight steel rod fastened near the lower extremity of the femur and pointed directly forward, and used as an indicator of internal and external rotation.
   b. A small steel rod in the lower end of femur. This rod is used to maintain either the vertical or flexed 90 degree position of the femur, by passing through copper loops at the different ends of a curved rod to be subsequently described.
   c. A steel rod, with a copper loop at each end, passed through lower portion of femur from side to side, horizontally. Copper hooks attached to strings may be dropped into the copper loops, that the femur may be manipulated without suspicion of being unconsciously influenced by the operator.
   d. Screw-eyes in femur represent insertions or functional insertions of muscles.
3. A rubber cord having a ring in one end for attachment to screw-hooks on rear of wooden upright. A copper hook at the other end for attaching to screw eyes in femur. This cord represents the muscle under demonstration.
4. A curved steel rod with a radius a little greater than length of femur and forming the arc for about a quadrant of a circle.

a. A copper loop, at lower end of rod, through which is passed the steel rod in the end of femur, when demonstrating functions with the femur hanging vertically.

b. A copper loop, at extreme upper end, through which is passed the steel rod in end of femur, when demonstrating functions with the femur flexed 90 degrees.

c. A horizontal rod at upper extremity, to each end of which is attached a string to be used for manipulating



PHOTOGRAPH 1171 shows the femur flexed 90°. The end of the femur is out of focus, and does not show the short steel rod by which it is supported in the copper loop attached to the curved steel rod. The pointer shows a few degrees of internal rotation. The muscle represented is the psoas. The position is one in which the psoas muscle is neutral in regard to rotation. If slight external rotation be produced, the rubber cord will complete external rotation. If slight internal rotation be produced, the rubber cord will complete internal rotation. See Fig. 2, drawing 1187, showing that internal rotation of 10°, from the natural position, will cause the line of traction to pass through the axis of rotation, and make the psoas muscle assume a neutral position, as shown in photograph 1171.

femur without giving rise to suspicion of unconsciously influencing motions by the hand. When the free end of the steel pointer on the femur lies in the plane of the curved steel rod, the femur is assumed to be in its natural position. Departure of the free end from this plane indicates rotation, either external or internal.

The model is intended for the active demonstration of internal and external rotation with the femur hanging vertically; femur flexed 90°, and during flexion from vertical position.

The passive demonstration of other functions may be made by noting that the conditions upon the model are similar to those upon the drawings.

This paper might prove interesting even if it were only a diagrammatic corroboration of the statements of standard anatomic textbooks; but the corroborative and dissenting portions are only incidental to the presentation of what I believe has not been stated previously, namely, the fact that some muscles of the hip have diametrically opposed functions, varying with the degree of flexion, rotation, abduction and adduction of the femur.

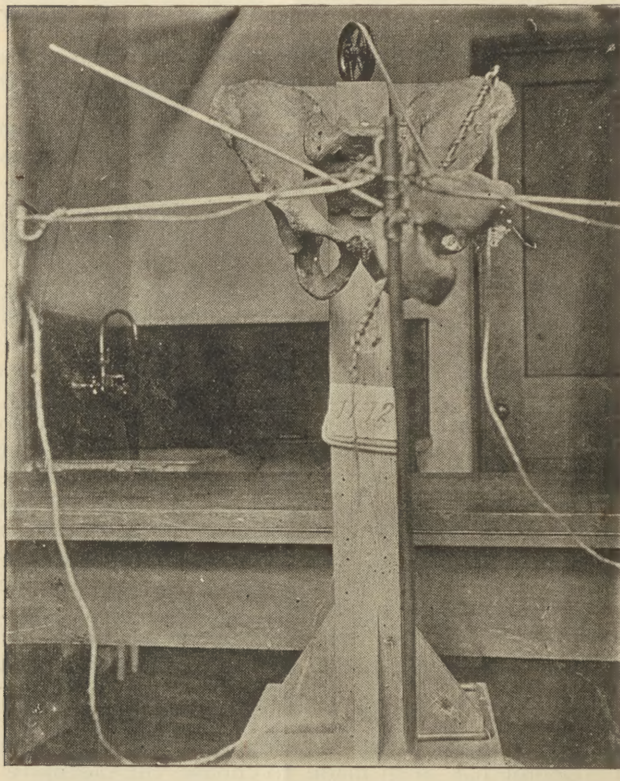
By this I do not mean changes in function, such as are mentioned in standard textbooks on anatomy, when the anterior fibers of a muscle are said to do so and so and the posterior fibers the reverse; but that opposite functions are performed by the same muscle in its entirety. For example, I believe I can show beyond doubt that the pectineus muscle is a powerful internal rotator as well as a powerful external rotator; an extensor as well as a flexor, etc. The capability of producing both flexion and extension might be readily apparent, but one would probably not declare the existence of capacity for internal and external rotation without previous diagrammatic or experimental work.

In locating points representing origin and insertion an attempt has been made to choose the meanposition, or the point around which the power exerted at the origin, or applied at the insertion, would balance.

This method has been used in all instances except with the gluteal muscles (with these the extreme limits of origin are used and the line dividing their opposing areas pointed out), and the adductor magnus in which shaft and condyle insertions are represented separately.

There are four terms which will be used frequently that should be defined here:

1. Functional origin.
2. Functional insertion.



PHOTOGRAPH 1172 is similar to 1171. The pointer shows much greater internal rotation. The muscle represented is the psoas. The femur was rotated slightly internally from the neutral position shown in photograph 1171, and the rubber cord immediately completed internal rotation, as shown.

3. Line of traction.
4. Axis of rotation.

By functional origin is meant the last point in the course of a muscle to its functional insertion which

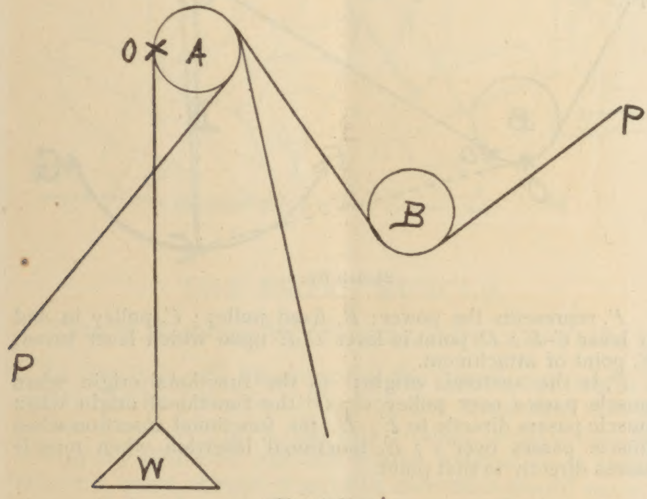
prevents that course from being a straight line. It is also the first point in the last straight line which ends with the functional insertion of the muscle.

The functional origin may be the anatomic origin, but frequently is not. To illustrate the meaning see sketch No. 1.

By functional insertion is meant the first point, on the bone to be moved, that terminates the straight line which begins at the functional origin. To illustrate the meaning see sketch No. 2.

The functional insertion may be the anatomic insertion, but is frequently not so.

By line of traction is meant the straight line joining functional origin and functional insertion.



Sketch No. 1.

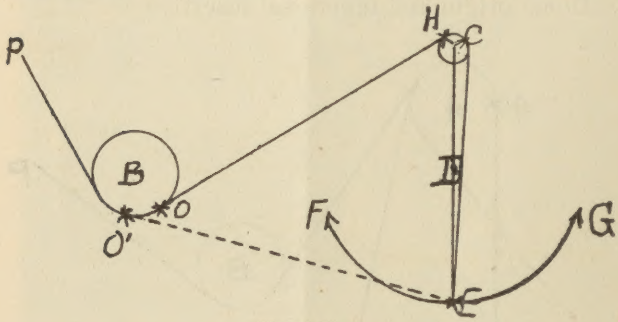
In the sketch No. 1, *A* and *B* represent fixed pulleys; *W*, the weight to be raised; *P*, three different locations of the power; *O*, the last point changing the direction of the cord.

P represents the anatomic origin; *A* and *B*, interruptions (bone and muscle) to the direct course of muscle; *W*, the bone to which muscle is attached; *O*, the functional origin.

To determine the direction in which *W*, the bone, will move, *P*, the anatomic origin, must be ignored and only *O*, the functional origin, considered.

By axis of rotation is meant a line passing through the center of the head of the femur and always at right angles to the plane of rotation. This differs from the meaning given by Morris, edition of 1898, but probably not enough to produce important changes in results.

Beginning with drawing 1188, Fig. 1. This shows what has been assumed as the correct position of the femur, seen from the front; the subject being in the erect position, with the inferior surfaces of condyles resting on horizontal plane. Fig. 3 shows the posterior surfaces of the condyles and shaft near greater trochanter, in a vertical plane at right angles to the



Sketch No. 2.

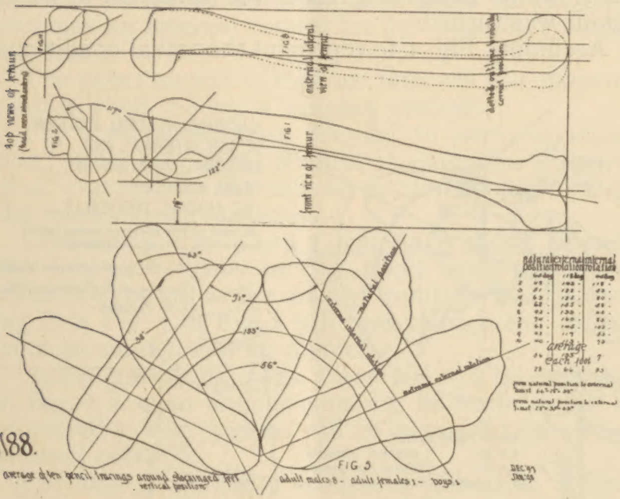
P, represents the power; *B*, fixed pulley; *C*, pulley in end of lever *C–E*; *D*, point in lever *C–E* upon which lever turns; *E*, point of attachment.

P, is the anatomic origin; *O*, the functional origin when muscle passes over pulley *C*; *O′* the functional origin when muscle passes directly to *E*; *H*, the functional insertion when muscle passes over *C*; *E*, functional insertion when muscle passes directly to that point.

horizontal plane mentioned. The angle of the axis of neck and shaft, 122°, approaches closely to that given by Morris in the edition of 1893, 125°.

Fig. 2 is a top view of Fig. 1. The angle of the axis of the neck and the antero-posterior vertical plane, 117°, is not to be found in Gray nor Morris. Fig. 5 shows the average attempts of 8 adult males, one adult female, and one boy, to produce extreme internal and external rotation. Fig. 5 also shows the

average divergence of the feet when the subject is standing naturally. It will be noticed that the arc of internal exceeds that of external rotation by the difference between 63° and 38°, or 25° for each foot.



1188.

THE PSOAS MUSCLE.

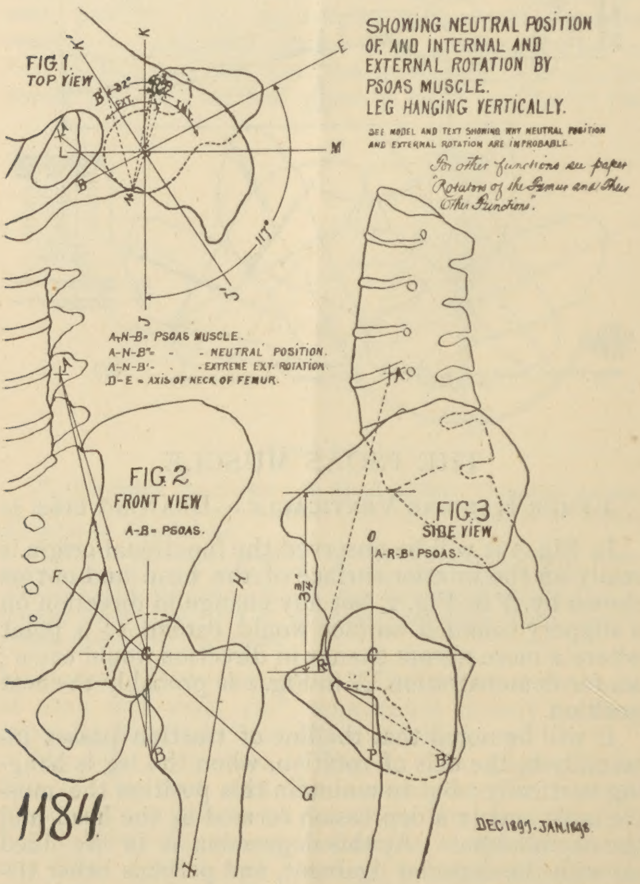
Femur Hanging Vertically.—Drawing 1184.

In Fig. 3 it will be observed the functional origin is really on the inferior surface of the head and not as shown by *N* in Fig. 1, but any change in direction on a slippery rounded surface would extend to a point where a more abrupt change in direction would occur; so, for demonstration, *N* in Fig. 1 is probably the best position.

It will be noted that the line of traction passes internally to the axis of rotation, when the leg is hanging vertically; but to maintain this position the muscle must rest in a depression formed by the head and the acetabulum. As this depression is in life filled up with the capsular ligament, and perhaps other tissues, the muscle would probably be thrown farther

outward, so that the line of traction would either pass through the axis of rotation or lie externally to it. If it passed through the axis of rotation, the action would be neutral, but would become either internal or external, rotation depending upon the direction in which femur was turned.

Assuming Fig. 1 to represent the actual conditions,



This drawing represents the action of the psoas muscle. *A.* in Figs. 1, 2, 3 is the origin, *N.* functional origin. *B.* in Figs. 1, 2, 3 is the insertion.

then will the psoas muscle rotate externally for 38° (see Fig. 5, drawing 1188) less 10° (shown in Fig. 1), or 28°. Or, if the femur be rotated internally only 10°, then will the psoas be neutral in action; but, if internal motion be continued, the psoas immediately becomes an internal rotator for 63° (see Fig. 5, drawing 1188).

The psoas muscle is then an internal and external rotator when the leg is hanging vertically.

Fig. 2 shows the psoas adapted to perform adduction; but a very slight amount of abduction will carry *A–B* external to the axis of rotation *C*, and change the muscle to an abductor.

Consulting Figs. 1 and 2 conjointly it will be seen that internal rotation in Fig. 1 will carry the line of traction external to the axis of rotation and projecting B in Fig. 1 to Fig. 2 will then change the muscle from an adductor to an abductor.

Again consulting Figs. 1 and 2 it will be seen that in Fig. 2 if even slight abduction be made and *B* be projected to Fig. 1, psoas will be in position for strong internal rotation.

Further, if in Fig. 2 moderate adduction from a position of abduction be made, *B* will be carried internal to the axis *C*, and if projected to Fig. 1 will show strong external rotation.

By the same reasoning, beginning with Fig. 1 and projecting to Fig. 2, external rotation will adapt the muscle for adduction if it has been in position for abduction.

Femur Flexed 90°.—Drawing 1187.

Fig. 2 shows the psoas as an external rotator, but internal rotation in excess of 10° makes it an internal rotator.

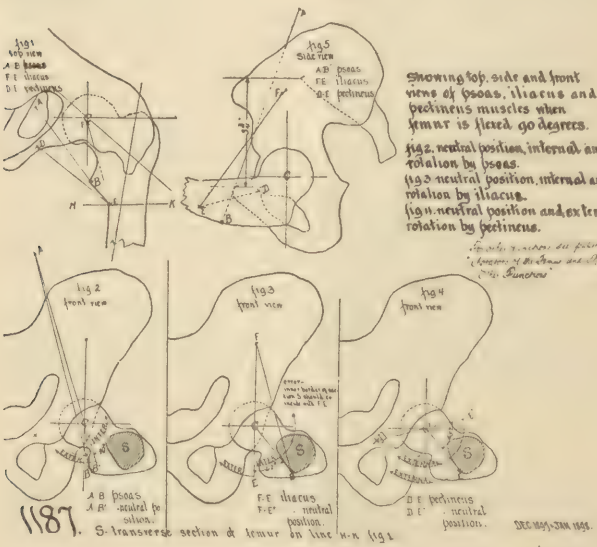
Fig. 1 shows adduction; Fig. 5, flexion.

With the leg in the natural position, the psoas is an external rotator at the beginning or shortly after the beginning of flexion, and continues so throughout flexion. But if flexion be preceded by slight internal rotation, say 15°, then the psoas acts all through flexion as an internal rotator.

To summarize; we find the psoas capable of performing the following functions:

FEMUR HANGING VERTICALLY OR NEARLY SO.

1.	Fig. 1,	Drawing 1184.	External rotation.
2.	Fig. 1,	"	Internal rotation.
3.	Figs. 1 and 2,	"	External rotation during adduction from position of abduction.
4.	Figs. 1 and 2,	"	Internal rotation during abduction.
5.	Fig. 2,	"	Adduction.
6.	Fig. 2,	"	Abduction during adduction.
7.	Figs. 1 and 2,	"	Abduction during internal rotation.
8.	Figs. 1 and 2,	"	Adduction during external rotation.
9.	Fig. 3.	"	Flexion.



FEMUR FLEXED 90°.

10.	Fig. 2,	Drawing 1187.	External rotation.
11.	Fig. 2,	"	Internal rotation.
12.	Fig. 1,	"	Adduction.
13.	Fig. 5,	"	Flexion.

DURING FLEXION.

14.	Fig. 1,	Drawing 1184.	External rotation.
15.	Fig. 2,	" 1187.	Internal rotation during internal rotation.

To prevent complication, lines illustrating some of these changes were not placed upon drawings.

Functions of the psoas as given by Gray, edition of 1897, are as follows:

"The psoas and iliacus muscles, acting from above, flex the thigh upon the pelvis, and, at the same time, rotate the femur outward. Acting from below," etc.

My first objection to this treatment of the psoas is the omission of important and pronounced functions.

My second is that the statement "and at the same time rotate the femur outward," is, I believe, incorrect. This will be explained when discussing the iliacus.

Morris, edition of 1898, says the psoas is an internal rotator. He credits this muscle when acting from above with no other function except that it may become an external rotator when the thigh is broken.

When in his description the words are noted, "The line of the tendon of the psoas passes either through or external to this axis" (the axis of rotation), it seems singular that he failed to note the possibility of external rotation. By way of comment I might say that nearly two years ago I pointed out in a brief way in an unpublished article (with a very limited distribution of an extract) that the psoas, pectineus and iliacus muscles each possessed opposing functions.

THE ILIACUS.

Femur Hanging Vertically.—Drawing 1185.

Fig. 1. *A-D-B*, shows internal rotation.

To reach a neutral position before beginning external rotation would require an impossible degree of external rotation; the possible limit upon drawing 1188 showing 38°, and drawing 1185 shows 41° required; hence there is no opposing function.

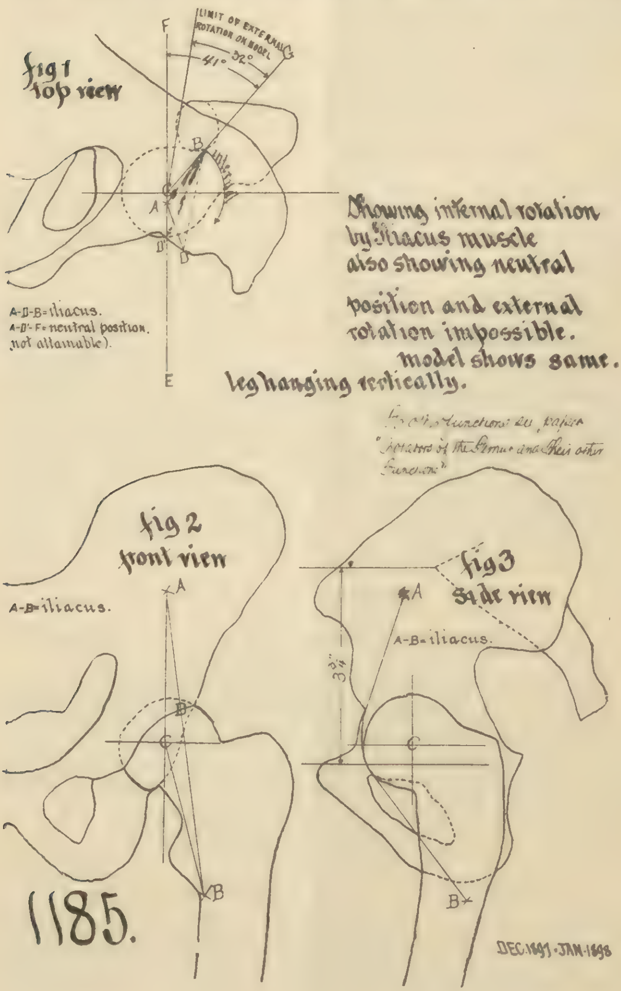
Fig. 2, shows abduction. Fig. 3, flexion.

Femur Flexed 90°.—Drawing 1187.

Fig. 1 is about neutral as regards abduction and adduction, and will oppose both. This condition will be demonstrated more clearly in other muscles later on.

Fig. 3, internal rotation and external rotation.

When the femur is hanging vertically, the first stoppage in external rotation is caused by the lesser trochanter coming in contact with the ischium. When the femur is flexed 90° the femur may be ex-



ternally rotated 90°, and the lesser trochanter will even then clear the pubes. This explains why in Fig. 3 external rotation is shown even after passing through 42° of external rotation to reach the neutral line.

During Flexion. (Shown by model.)

The iliacus is an internal rotator all through flexion. But if flexion is preceded by external rotation of about 30°, it soon becomes an external rotator and remains so during the remainder of flexion. The difference of 30° on the model and 42° in the Fig. 3 is one of the "differences of kind" spoken of previously.

Fig. 5 shows flexion.

Summary of thf Functions of the Iliacus.

FEMUR HANGING VERTICALLY.

1. Fig. 1.	Drawing 1185.	Internal rotation.
2. Fig. 2.	"	Abduction.
3. Fig. 3.	"	Flexion.

FLEXED 90°.

4. Fig. 1.	Drawing 1187.	Neutral, opposing slightly abduction and adduction.
5. Fig. 3.	"	Internal rotation.
6. Fig. 3.	"	External rotation.
7. Fig. 5.	"	Flexion.

DURING FLEXION.

8. Model. Internal rotation.
9. Model. External rotation when preceded by external rotation of about 30 degrees.

Of the iliacus, Gray, edition of 1897, says, "The psoas and iliacus muscles, acting from above, flex the thigh upon the pelvis, and, at the same time, rotate the femur outward."

Morris, edition of 1898, says, "Action, similar to that of the psoas, as a flexor of the thigh." The muscle is certainly a strong internal rotator when the femur is hanging vertically and should receive credit for it. I think I have shown Gray to be in error in regarding it as an external rotator in flexion, except when external rotation precedes flexion. In flexion the psoas and iliacus oppose each other in rotative tendencies.

PECTINEUS MUSCLE.

Femur Hanging Vertically.—Drawing 1186.

This muscle is a superb illustration of opposing functions possessed by a muscle in its entirety.

Fig. 1 shows the muscle to be an external rotator, but 20° of internal rotation makes it neutral in action and in any further internal rotation it becomes an active powerful agent.

Fig. 2 shows adduction, Fig. 3, flexion.

Femur Flexed 90°.—Drawing 1187.

Fig. 1 shows adduction.

Fig. 4 shows external rotation.

Fig. 5 shows flexion. Consulting Fig. 5 it will be seen the pectineus has almost ceased being a flexor and exerts all its force in adduction and external rotation.

Extreme Flexion.

From Fig. 5 it will be seen that when flexed to the utmost *E* will be at a higher elevation than *D;* the muscle will then become an extensor.

During Flexion. (Illustrated by Model.)

Beginning flexion as an external rotator (see Fig. 1, drawing 1186) and ending at 90° flexion as an external rotator (see Fig. 4, drawing 1187), it is evident that it performs that function throughout flexion. But if flexion be preceded by internal rotation of anything over 20° it will remain an internal rotator until flexion reaches about 90° when it will suddenly change to an external rotator.

Summary of Functions of Pectineus.

FEMUR HANGING VERTICALLY.

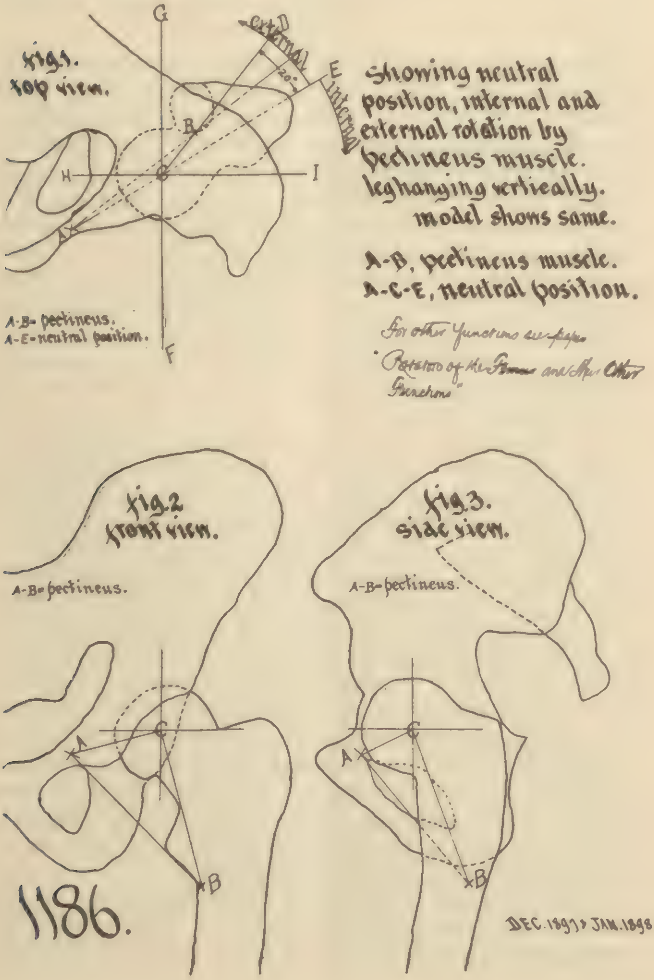
1.	Fig. 1.	Drawing 1186.	Internal rotation.
2.	Fig. 1.	" "	External rotation.
3.	Fig. 2.	" "	Adduction.
4.	Fig. 3.	" "	Flexion.

FEMUR FLEXED 90°.

5. Fig. 1. Drawing 1187. Adduction.
6. Fig. 4. " " External rotation.
7. Fig. 5. " " Flexion.

EXTREME FLEXION.

8. Fig. 5. Drawing 1187. Extension.



DURING FLEXION.

9. Fig. 1.	Drawing	1186.	External rotation.
9. Fig. 4.	"	1187.	External rotation.
10. Model.			Internal rotation, when preceded by internal rotation greater than 20°.
11. "			Sudden external rotation when preceded by internal rotation greater than 20° and when flexion has reached 90°.

Of the pectineus, Gray, edition 1897, says, "The pectineus and three adductors adduct the thigh powerfully; they are especially used in horseback exercise, the flanks of the horse being grasped between the knees by the action of these muscles. In consequence of the obliquity of their insertion into the linea aspera they rotate the thigh outward, assisting the external rotators, and when the limb has been abducted they draw it inward, carrying the thigh across that of the opposite side. The pectineus and adductors brevis and longus assist the psoas and iliacus in flexing the thigh upon the pelvis. In progression, also, all these muscles assist in drawing forward the hinder limb."

In substance, adduction, external rotation, and flexion are functions named. The muscle is certainly a powerful internal rotator under conditions previously mentioned, as manipulation of the model will show.

Morris says, edition of 1898, "action, to flex and at the same time adduct the thigh; as for example in crossing the legs, when one thigh is brought forward and inward to place it in front of the other thigh. It is also a slight external rotator. Its predominant action is that of flexion, as is indicated by the fact that it receives the same nerve-supply as the sartorius and ilio-psoas. The tendency which it has to adduct during flexion is counteracted by the slight abduction produced by the sartorius. They will together produce a slight external rotation, as may be observed by the advance of the leg in walking." In substance, external rotation, flexion, adduction.

I cannot agree with Morris in the following: 1. "It is also a slight external rotator." Fig. 1, drawing 1186, shows that at the limits of internal and external

rotation it is a *very powerful* agent, more so in internal rotation than external, owing to the greater arc of rotation; but Morris, like Gray, does not mention internal rotation among its function.

2. "Its predominant action is that of flexion." Measuring perpendicular lines from centers of rotation to lines of traction (a method which indicates the leverage), in Fig. 1, drawing 1187, Fig. 2, drawing 1186, and comparing with Fig. 5, drawing 1187, and Fig. 3, drawing 1186, we find in both instances adduction largely exceeds flexion. With the femur hanging vertically, adduction is 50% greater than flexion. With femur flexed at 90°, adduction is three times as great as flexion. Adduction with flexion at 90° is nearly 25% greater than the same function with femur hanging vertically.

It would be interesting to measure the relative values of all the muscles shown in the drawings, but time will not permit.

GLUTEUS MAXIMUS.

Femur Hanging Vertically.—Drawing 1189.

The same letters in Figs. 1, 2, and 3 refer to the same point.

Figure 1. Crest from *E* to *A* is that part of origin producing internal rotation (see same origin in Figs. 2 and 3). Functional insertion is *B′*. Balance of muscle *A* to end of coccyx is that part of origin causing external rotation; insertion at *B*.

Division is clearly shown by *A–B′* in Fig. 3.

Figure 2 shows abduction by *E* to *F* (better shown in Fig. 3) with functional insertion at *B′* and partly at *B*.

Figure 2 shows adduction by *F* to end (better seen in Fig. 3), insertion at *B*.

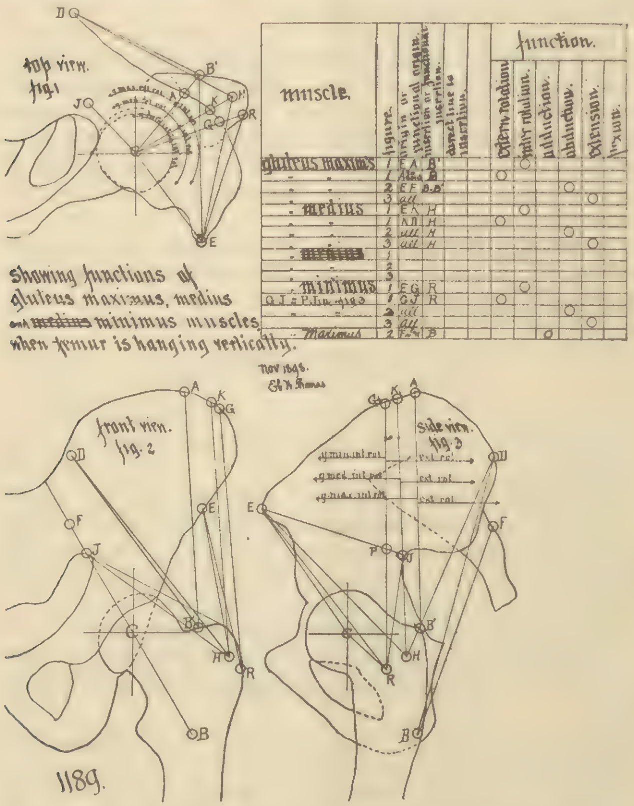
Figure 3 shows extension by the entire muscle with functional insertions at *B* and *B′*.

I do not favor the idea of a muscle acting by parts, but treat the subject that way because anatomists do so.

Femur Flexed 90°.—Drawing 1190.

(See table on drawing for functions.)

Lines of traction $E\text{–}B$ and $W\text{–}B$ are only to show what might occur should the muscle slip off from the functional insertions at B'' and B' and pull directly from origin at B; this would mean flexion by almost the entire muscle.



Summary of Functions of Gluteus Maximus.

FEMUR HANGING VERTICALLY.

1. Fig. 1. Drawing 1189. External rotation by part of the muscle.
2. Fig. 1. " " Internal rotation by part of the muscle.

3. Fig. 2.	Drawing 1189.	Abduction by part of the muscle.
4. Fig. 2.	" "	Adduction by part of the muscle.
5. Fig. 5.	" "	Extension by all of the muscle.
	FEMUR FLEXED 90°.	
6. Fig. 1.	Drawing 1190.	Abduction by part of the muscle.
7. Fig. 1.	" "	Adduction by part of the muscle.
8. Fig. 2.	" "	Internal rotation, by part of the muscle.
9. Fig. 2.	" "	External rotation, by part of the muscle.
10. Fig. 3.	" "	Flexion by part of the muscle.
11. Fig. 3.	" "	Extension by part of the muscle.

Morris, edition of 1898, says: "Extension, external rotation, upper fibers abduct, and lower adduct."

Gray, edition of 1897, says: "Extension, lower part acts as an abductor and external rotator."

As Morris gives some of the functions performed by *parts* of the muscle, internal rotation and flexion should be included; the same may be said of Gray.

Gray is in error in saying "the lower part acts as an abductor" if he means with the femur in vertical position. See Fig. 2, drawing 1189; the function of the muscle in this condition is adduction.

GLUTEUS MEDIUS.

Femur Hanging Vertically.—Drawing 1189.

See table for functions. Note that as a rotator the muscle acts in parts (see Figs. 1 and 3), but in abduction (Fig. 2) and extension (Fig. 3) it acts as a whole.

Femur Flexed 90°.—Drawing 1190.

See table for functions. In internal rotation (Fig. 2) only does it act as a unit.

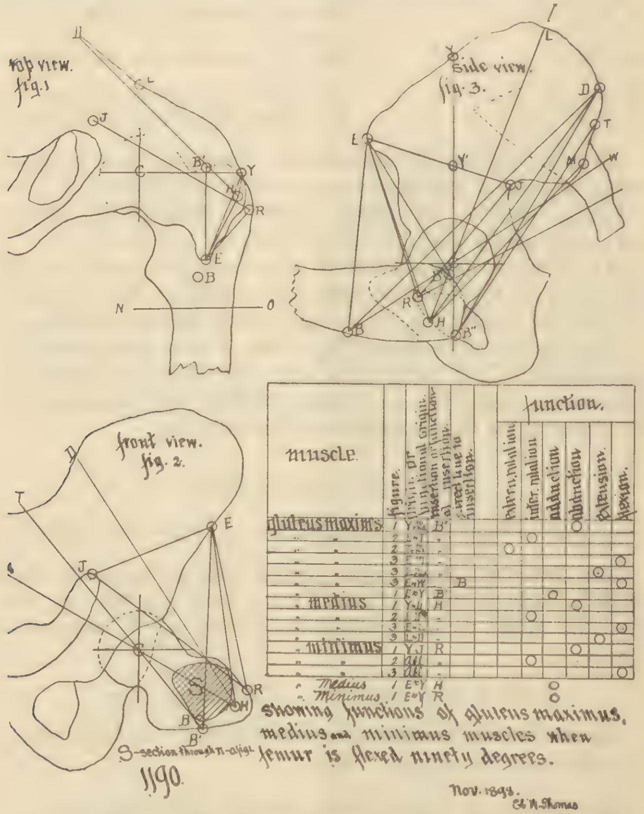
Summary of Functions of Gluteus Medius.

FEMUR HANGING VERTICALLY.

1. Fig. 1.	Drawing 1189.	Internal rotation by part of the muscle.
2. Fig. 1.	" "	External rotation by part of the muscle.
3. Fig. 2.	" "	Abduction by whole of the muscle.
4. Fig. 3.	" "	Extension by whole of the muscle.

FEMUR FLEXED 90°.

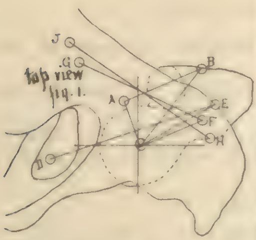
5. Fig. 1.	Drawing 1190.	Abduction by part of muscle.
6. Fig. 1.	"	"	Adduction by part of muscle.
7. Fig. 2.	"	"	Internal rotation by whole of muscle.
8. Fig. 3.	"	"	Flexion by part of muscle.
9. Fig. 3.	"	"	Extension by part of muscle.



Concerning the functions of the gluteus medius Morris (edition of 1898) says, "Abduction—anterior fibres rotate inward; posterior rotate outward."

Gray (edition of 1897) says of the gluteus medius and minimus, they "abduct when thigh is extended." "Anterior fibers rotate inward; posterior fibers rotate outward."

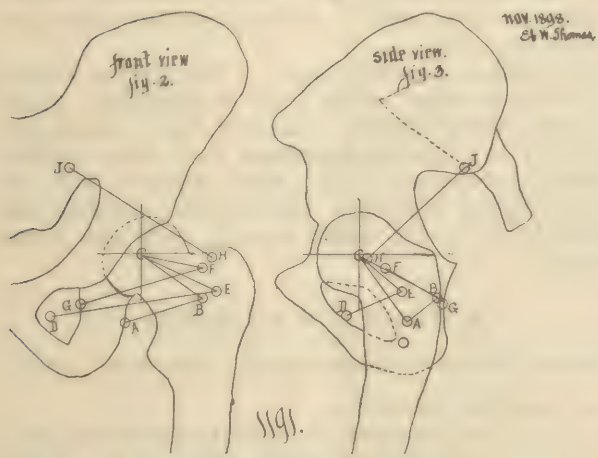
Neither Gray nor Morris mention extension by the entire muscle when the femur hangs vertically. Neither mentions the functions after flexion nor points out the interesting changes in function.



muscle.	figure	origin or functional origin.	insertion or functional insertion.			exter. rotation.	inter. rotation.	adduction.	abduction.	extension.	flexion.
quadratus femoris	1	A	B			O					
"	2	"	"					O			
"	3	"	"								O
obturator externus	1	D	E			O					
"	2	"	"					O			
"	3	"	"								O
internus	1	G	F			O					
"	2	"	"					O			
"	3	"	"	returns [illegible] extension to neutral.							
pyriformis	1	J	H			O					
"	2	"	"						O		
"	3	"	"							O	

showing functions of quadratus femoris, obturators externus and internus, and pyriformis muscles when femur is hanging vertically.

nov. 1898.
Ed W. Thomas



GLUTEUS MINIMUS.

Femur Hanging Vertically.—Drawing 1189.

See table for functions. The line *E–J*, Fig. 3, gives line of origin, and *P–J*, in Fig. 3, represents *G–J* in table.

Femur Flexed 90°.—Drawing 1190.

See table for functions.

Summary of Functions of Gluteus Minimus.

FEMUR HANGING VERTICALLY.

1.	Fig. 1.	Drawing 1189.	Internal rotation by part of the muscle.
2.	Fig. 1.	" "	External rotation by part of the muscle.
3.	Fig. 2.	" "	Abduction by whole of the muscle.
4.	Fig. 3.	" "	Extension by whole of the muscle.

FEMUR FLEXED 90°.

5.	Fig. 1.	Drawing 1190.	Abduction by part of the muscle.
6.	Fig. 1.	" "	Adduction by part of the muscle.
7.	Fig. 2.	" "	Internal rotation by whole of the muscle.
8.	Fig. 3.	" "	Flexion by whole of the muscle.

Of the functions of the gluteus minimus, Morris (edition of 1898) says: "Same as medius abduction, rotation inward."

Gray (edition of 1897) says: "The gluteus medius and minimus abduct when limb is extended. Anterior fibers rotate inward; posterior fibers rotate outward." The following functions have been omitted by both: extension by the whole muscle, with the femur hanging vertically, and internal rotation and flexion, both by the whole muscle, with the femur flexed 90°.

QUADRATUS FEMORIS.

Femur Hanging Vertically.—Drawing 1191.

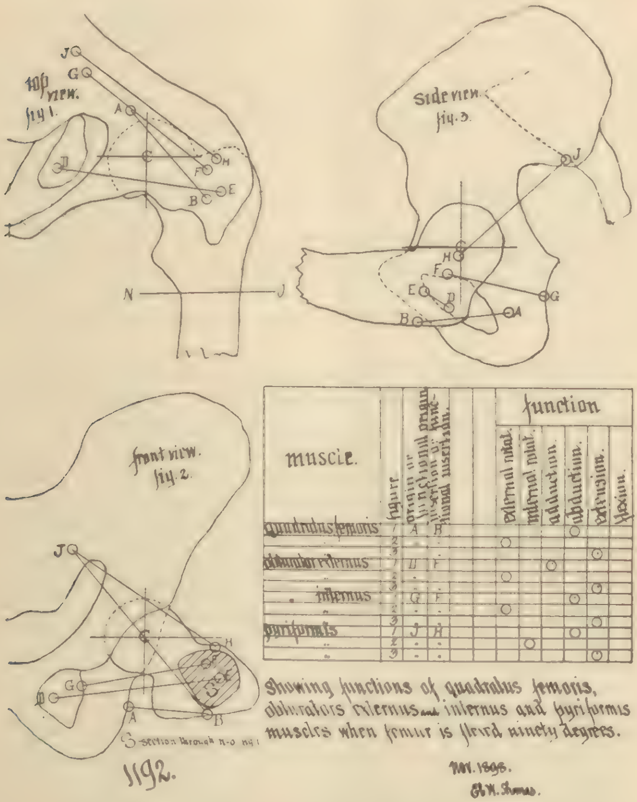
For functions see table.

In Fig. 3 the insertion *B* is posterior to the origin *A*, but so slightly that when the femur is flexed only to a small extent *B* will be carried anterior to origin *A* and the muscle will change its function from flexion to extension.

In going upstairs this change of function will occur at every step and very likely occurs at every step on the level, but only to a limited extent.

Femur Flexed 90°.—Drawing 1192.

See table for functions, and in Fig. 3 note the extent to which *B* passed anterior to *A* in changing function from flexion to extension.



Summary of Functions of Quadratus Femoris.

FEMUR HANGING VERTICALLY.

1.	Fig. 1.	Drawing 1191.	External rotation.
2.	Fig. 2.	" "	Adduction.
3.	Fig. 3.	" "	Flexion.
4.	Fig. 3.	" "	Extension.

FEMUR FLEXED 90°.

5. Fig. 1. Drawing 1192. Abduction.
6. Fig. 2. " " External rotation.
7. Fig. 3. " " Extension.

Of the quadratus femoris, Morris (edition of 1898) says, "external rotator."

Gray (edition of 1897) says: "The remaining muscles [pyriformis, gemellus superior, obturator internus, gemellus inferior, obturator externus, and quadratus femoris] are powerful rotators of the thigh outward. In the sitting position when the thigh is flexed upon the pelvis, action as rotator ceases and they become abductors, with the exception of the obturator externus, which still rotates the femur outward."

Consulting Fig. 1, drawing 1191, and Fig. 2, 1192, it will be seen that Gray is in error in saying that the function of rotation is lost by flexion. Fig. 2, drawing 1192, shows that the power of rotation has been increased.

In mentioning abduction as one of the functions occurring with or after flexion does he not fail to mention a very interesting fact in not stating this is a reversal of a previous function of adduction?

The conditions in Fig. 2, drawing 1191, are much more favorable for adduction than those of Fig. 1, drawing 1192 are for abduction, unless we regard the further shortening of *A—B*, Fig. 2, drawing 1191, as impossible or with greatly diminished power. Length of *A—B* in Fig. 2, drawing 1191, is 70% of *A—B*, Fig. 1, drawing 1192, but the leverage of the first is 3½ times the second.

OBTURATOR EXTERNUS.

Femur Hanging Vertically.—Drawing 1191.

In Fig. 1 it would appear as if this muscle *D—E* could also perform internal rotation if the femur was internally rotated a few degrees, but during internal rotation the muscle is curved around the head and neck of the femur in such a way as to change the functional insertion and always keep the line of traction posterior to the axis of rotation.

For functions see table.

Femur Flexed 90°.—Drawing 1192.

For functions, see table.

Summary of Functions of Obturator Externus.

FEMUR HANGING VERTICALLY.

1.	Fig. 1,	Drawing 1191.	External rotation.
2.	Fig. 2.	"	Adduction.
3.	Fig. 3.	"	Flexion.

FEMUR FLEXED 90°.—DRAWING 1192.

4.	Fig. 1.	Drawing 1192.	Adduction.
5.	Fig. 2.	"	Eternal rotation.
6.	Fig. 3.	"	Extension.

Morris (edition of 1898) says: "External rotation, adduction."

Gray (edition of 1897) says: "External rotation. Adduction and external rotation in sitting position."

OBTURATOR INTERNUS.

For functions see tables on drawings 1191 and 1192.

Referring to Fig. 3, drawing 1191, muscle *G*, *F*, it is apparent the muscle will resist both extension and flexion and endeavor to maintain neutral position, and has the two functions of flexion and extension.

The conditions and results form a striking contrast with conditions and results of the pectineus, Fig. 1, drawing 1186, where the line of traction passes through the axis of rotation. In the latter the constant tendency is departure, to one side or the other, from the neutral position. In case of the pectineus the axis of rotation lies between origin and insertion and constitutes an intermediate point in a line connecting origin, insertion and axis of rotation; while in the case of the obturator internus the axis of rotation is a terminal point in that line. These conditions, more or less modified, characterize all muscles having individually opposing functions.

Summary of Functions of Obturator Internus.

FEMUR HANGING VERTICALLY.

1.	Fig. 1.	Drawing	1191.	External rotation.
2.	Fig. 2.	"	"	Adduction.
3.	Fig. 3.	"	"	Flexion.
4.	Fig. 3.	"	"	Extension.

FEMUR FLEXED 90°.

5. Fig. 1.	Drawing 1192.		Abduction.
6. Fig. 2.	"	"	External rotation.
7. Fig. 3.	"	"	Extension.

Of this muscle and the gemelli Morris (edition of 1898) says: "Rotate outward: abduct, when thigh is bent, through right angle."

Gray (edition of 1897) says: "Outward rotation. Loss of rotation in sitting position; abduction in sitting position."

My investigations show that external rotation is *not* lost in sitting position (see Fig. 2, drawing 1192). Neither Gray nor Morris mentions that adduction in the vertical position is nearly equal to abduction in the sitting position.

PYRIFORMIS.

(See tables for functions.)

Summary.

FEMUR HANGING VERTICALLY.

1. Fig. 1.	Drawing 1191.		External rotation.
2. Fig. 2.	"	"	Abduction.
3. Fig. 3.	"	"	Extension (very slight).

FEMUR FLEXED 90°.

4. Fig. 1.	Drawing 1192.		Abduction.
5. Fig. 2.	"	"	Internal rotation.
6. Fig. 3.	"	"	Extension (very slight).

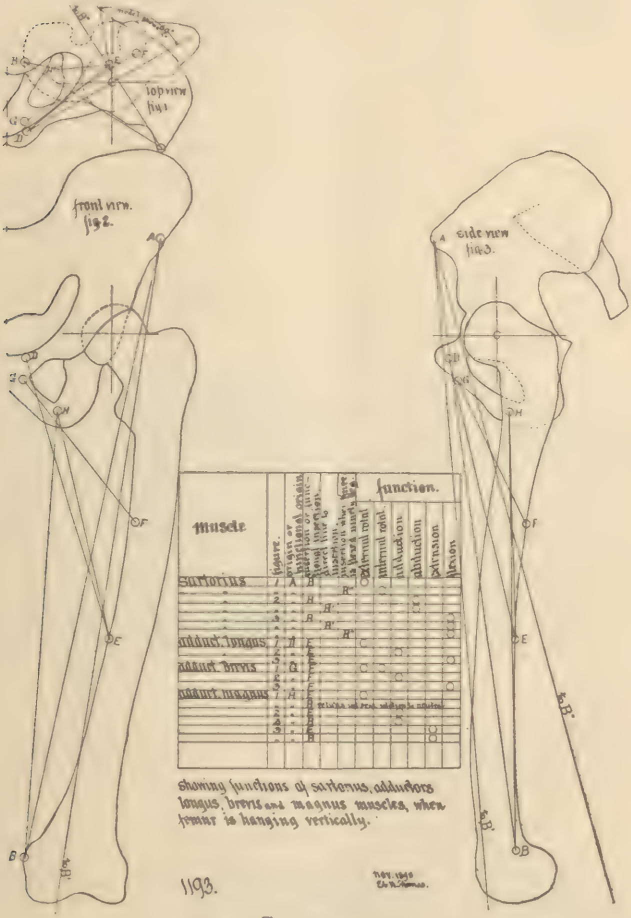
Morris (edition of 1898) says: "Outward rotation. Will abduct thigh when flexed."

Gray (edition of 1897) says: "Outward rotation. Outward rotation lost in sitting position. Abductor in sitting position."

I note abduction in both standing and sitting positions. The statement that there is loss of external rotation in the sitting position is correct, but no mention is made of the substitution of internal rotation.

SARTORIUS.

See tables for functions.



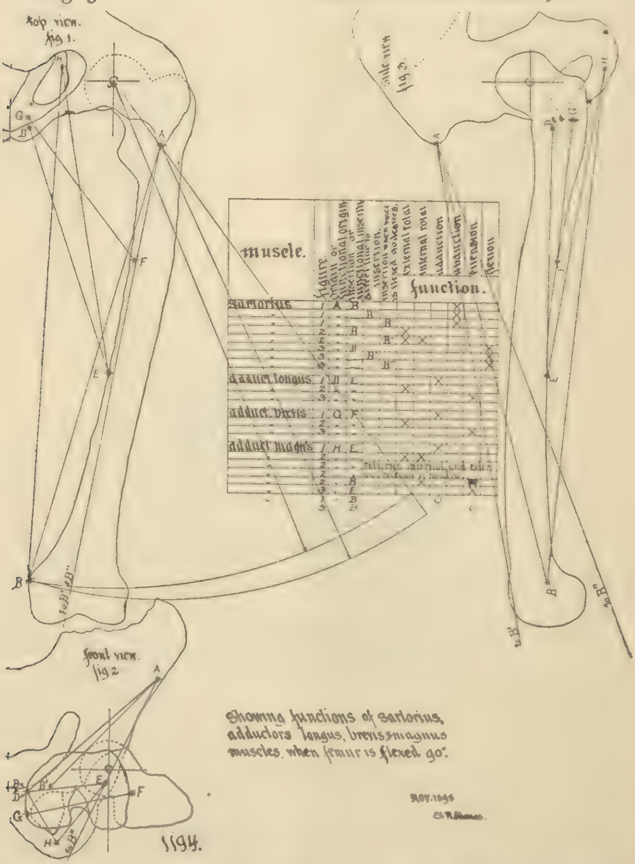
Summary.

FEMUR HANGING VERTICALLY.

1. Fig. 1. Drawing 1193. External rotation.
2. Fig. 1. " " Internal rotation with knee flexed 90°.
3. Fig. 2. " " Abduction.
4. Fig. 3. " " Flexion.
5. Fig. 3. " " Flexion with knee flexed 90°.

FEMUR FLEXED 90°.

6.	Fig. 1.	Drawing 1194.	Abduction.
7.	Fig. 1.	" "	Abduction with knee flexed 90°.
8.	Fig. 2.	" "	External rotation.
9.	Fig. 2.	" "	External rotation with knee flexed 90°.
10.	Fig. 2.	" "	Internal rotation with knee flexed 90°.
11.	Fig. 3.	" "	Flexion.
12.	Fig. 3.	" "	Flexion with knee flexed 90°.



Of the sartorius, Gray (edition of 1897) says, "with flexion, rotates thigh outwards; knee bent, assists rotation inwards."

Morris (1898) says: "Flexes thigh, at same time slight outward rotation and abduction. Flexes knee and when bent will help rotate inwards."

ADDUCTOR LONGUS.

Drawings 1193 and 1194.

Summary.

FEMUR HANGING VERTICALLY.

1. Fig. 1.	Drawing 1193.		External rotation.
2. Fig. 2.	"	"	Adduction.
3. Fig. 3.	"	"	Flexion.

FEMUR FLEXED 90°.

4. Fig. 1.	Drawing 1194.		Adduction.
5. Fig. 2.	"	"	External rotation.
6. Fig. 3.	"	"	Extension.

Gray (1897) says: "The pectineus and the three adductors adduct powerfully. In consequence of the obliquity of their insertion into the linea aspera they rotate outward. When the limb has been abducted they draw it inward. The pectineus and adductor longus and brevis assist the psoas and iliacus in flexing the thigh."

Morris (1898) says: "Adduction, flexion and at same time rotation outward."

Drawings 1193 and 1194 show that flexion ceases at 60°.

ADDUCTOR BREVIS.

See tables for functions, drawings 1193 and 1194.

Summary.

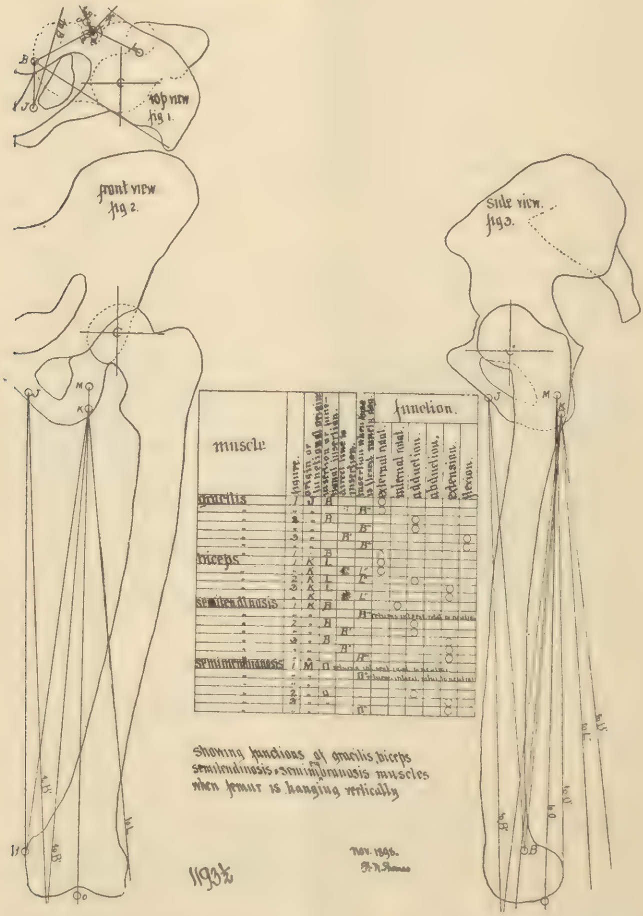
FEMUR HANGING VERTICALLY.

1. Fig. 1.	Drawing 1893.		External rotation.
2. Fig. 1.	"	"	Internal rotation, but will require first internal rotation of 25° to reach neutral line.
3. Fig. 2.	"	"	Adduction.
4. Fig. 3.	"	"	Flexion.

FEMUR FLEXED 90°.

5. Fig. 1.	Drawing 1894.		Adduction.
6. Fig. 2.	"	"	External rotation.
7. Fig. 3.	"	"	Extension.

Gray (1897) says: "Adduction, outward rotation, when limb has been abducted will draw it inward; flexion."



Morris (1898): "Adduction; outward rotation; will not assist powerfully in flexion."

Fig. 3, drawing 1193, shows the flexion-limit to be 40°.

ADDUCTOR MAGNUS.

In drawings 1193 and 1194 *E* represents the insertion of this muscle in the shaft and *B* the insertion in the adductor tubercle of condyle. The action of each is given separately.

FEMUR HANGING VERTICALLY.

1.	Fig. 1.	Drawing 1193.	External rotation.
2.	Fig. 2.	" "	Adduction.
3.	Fig. 3.	" "	Extension.
4.	Fig. 1.	" "	External rotation, action of tubercle insertion.
5.	Fig. 1.	" "	Internal rotation, action of tubercle insertion.
6.	Fig. 2.	" "	Adduction, action of tubercle insertion.
7.	Fig. 3.	" "	Extension, action of tubercle insertion.

FEMUR FLEXED 90°.

8.	Fig. 1.	Drawing 1194.	Adduction.
9.	Fig. 2.	" "	External rotation.
10.	Fig. 2.	" "	Internal rotation.
11.	Fig. 3.	" "	Extension.
12.	Fig. 1.	" "	Adduction, action of tubercle insertion.
13.	Fig. 2.	" "	Internal rotation, action of tubercle insertion.
14.	Fig. 3.	" "	Extension action, of tubercle insertion.

FEMUR LOWERED THREE INCHES.

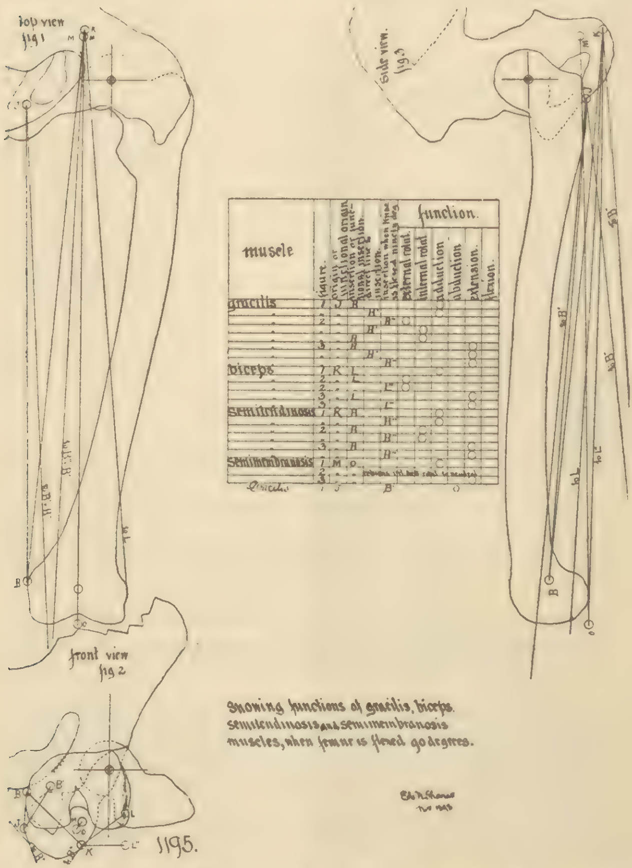
15. Fig. 2, drawing 1194. External rotation, action of tubercle insertion.

Gray (1897) says: "Adduction; outward rotation; when limb has been abducted, they draw it inward."

Morris (1898) says: "Upper three-fourths rotate outward; part rising from tuber ischii and inserted into condyle rotates slightly inwards, at the same time extends and adducts thigh."

GRAY.	MORRIS.	
Adduction.	Outward rotation.	
Outward rotation.	Inward rotation,	By action of tubercle insertion.
	Extension,	
	Adduction.	

Comparing with Morris my investigations show that the part having insertion in the tubercle has, in 90° flexion, the functions he mentions. Hanging vertically it has the same functions plus external rotation. The part inserted into the shaft has, in addition



to the function he names, adduction and extension when hanging vertically, and adduction, extension and internal rotation when flexion of 90° exists.

Referring to Fig. 2, drawing 1194, it is evident that, if the femur be lowered a few inches, as soon as *B*

becomes less elevated than H, the function of $H—B$ is reversed, becoming an external rotator.

GRACILIS.

SUMMARY.—DRAWINGS 1193½ AND 1195.

FEMUR HANGING VERTICALLY.

1.	Fig. 1.	Drawing 1193½.	External rotation.
2.	Fig. 2.	" "	Adduction.
3.	Fig. 3.	" "	Flexion.
4.	Fig. 1.	" "	External rotation, with knee flexed 90°.
5.	Fig. 2.	" "	Adduction, with knee flexed 90°.
6.	Fig. 3.	" "	Flexion, with knee flexed 90°.

FEMUR FLEXED 90°.

7.	Fig. 1.	Drawing 1195.	Adduction.
8.	Fig. 2.	" "	Internal rotation.
9.	Fig. 2.	" "	External rotation by lowering the femur 2 or 3 inches.
10.	Fig. 3.	" "	Extension.
11.	Fig. 1.	" "	Adduction, with knee flexed 90°.
12.	Fig. 2.	" "	External rotation, with knee flexed 90°.
13.	Fig. 3.	" "	Extension, with knee flexed 90°.

Morris says: "It adducts the thigh and flexes the knee; rotation inward when knee is flexed." Gray says: "It assists the sartorius in flexing the leg and rotating it inward; it adducts the thigh." Both agree on internal rotation when knee is flexed. My demonstration shows external rotation.

BICEPS.

SUMMARY.

FEMUR HANGING VERTICALLY.

1.	Fig. 1.	Drawing 1193½.	External rotation.
2.	Fig. 2.	" "	Adduction.
3	Fig. 3.	" "	Extension.
4.	Fig. 1.	" "	External rotation with knee flexed 90°.
5.	Fig. 2.	" "	Adduction with knee flexed 90°.
6.	Fig. 3.	" "	Extension with knee flexed 90°.

FEMUR FLEXED 90°.

7. Fig. 1.	Drawing 1195.		Adduction.
8. Fig. 2.	"	"	External rotation.
9. Fig. 3.	"	"	Extension.
10. Fig. 1.	"	"	Adduction with knee flexed 90°.
11. Fig. 2.	"	"	External rotation with knee flexed 90°.
12. Fig. 3.	"	"	Extension with knee flexed 90°.

Morris says it "extends the hip; flexes the knee. With knee flexed both heads rotate outward. Knee extended, long head rotates outward slightly."

Gray says: "The hamstring muscles flex the leg upon the thigh. When the knee is semi-flexed, the biceps, in consequence of its oblique insertion downward and outward, rotates the leg slightly outward. The semitendinosus and, to a slight extent, the semimembranosus rotate the leg inward, assisting the popliteus."

SEMITENDINOSUS.

Summary.

FEMUR HANGING VERTICALLY.

1. Fig. 1.	Drawing 1193½.		Internal rotation.
2. Fig. 2.	"	"	Adduction.
3. Fig. 3.	"	"	Extension.
4. Fig. 1.	"	"	Internal rotation, with knee flexed 90°.
5. Fig. 1.	"	"	External rotation, with knee flexed 90°.
6. Fig. 2.	"	"	Adduction, with knee flexed 90°.
7. Fig. 3.		"	Extension, with knee flexed 90°.

FEMUR FLEXED 90°.

8. Fig. 1.	Drawing 1195.		Adduction.
9. Fig. 2.	"	"	Internal rotation.
10. Fig. 3.	"	"	Extension.
11. Fig. 1.	"	"	Adduction, with knee flexed 90°.
12. Fig. 2.	"	"	Internal rotation, with knee flexed 90°.
13. Fig. 3.	"	"	Extension, with knee flexed 90°.

Morris (1898) says it "extends hip, flexes knee. With knee flexed, rotation inward." For Gray, see biceps.

SEMIMEMBRANOSUS.

SUMMARY.

FEMUR HANGING VERTICALLY.

1.	Fig. 1.	Drawing 1193½.	Internal rotation.
2.	Fig. 1.	" "	External rotation.
3.	Fig. 2.	" "	Adduction.
4.	Fig. 3.	" "	Extension.
5.	Fig. 1.	" "	Internal rotation with knee flexed 90°.
6.	Fig. 1.	" "	External rotation with knee flexed 90°.
7.	Fig. 2.	" "	Adduction with knee flexed 90°.
8.	Fig. 3.	" "	Extension with knee flexed 90°.

FEMUR FLEXED 90°.

9.	Fig. 1.	Drawing 1195.	Adduction.
10.	Fig. 2.	" "	Internal rotation.
11.	Fig. 2.	" "	External rotation.
12	Fig. 3.	" "	Extension.
13	Fig. 1.	" "	Adduction with knee flexed 90°.
14.	Fig. 2.	" "	Internal rotation with knee flexed 90°.
15.	Fig. 2.	" "	External rotation with knee flexed 90°.
16.	Fig. 3.	" "	Extension with knee flexed 90°.

Morris says it "extends the hip, and flexes the knee. With the knee flexed, internal rotation." Gray (see biceps).

Nos. 1196 and 1197 show a summary of all the opposing functions of the rotators of the hip having their insertions in the femur. This summary includes the glutei muscles, in which one part of a muscle acts in opposition to another part of the same muscle. A very few of these instances of the opposing action of parts of the glutei are mentioned by Gray and Morris.

Among some of the problems, the correct solution of which might reduce the importance, and might even prove the non-existence of some of the results of my diagrammatic demonstrations, are:

With what degree of fixity are the relations of muscles to one another maintained?

Are the intermuscular tissues sufficiently loose or elastic to permit of independence of action by each muscle?

Can the axis of traction in a long muscle extend from bony pelvic origins or trochlear surfaces to insertions on the femur?

Summary of opposing functions performed by rotators of the femur having bony insertions.

Muscle.	Drawing.	Figure.	Femur: Vertical.	Flexed going.	During flexion.	Knee: Flexed.	Not flexed.	Function: Exter. Rotation.	Inter. Rotation.	Adduction.	Abduction.	Extension.	Flexion.	Opposing Function: Exter. Rotation.	Inter. Rotation.	adduction.	Abduction.	Extension.	Flexion.	Manipulation to demonstrate opposing function
Psoas 1	1184	1	O					O							O					Internal rotation exceeding 10 degs.
" 2	"	1.2	O					O							O					Abduction (slight)
" 3	"	"	O						O					O						adduction from position of abduction.
" 4	"	2	O							O							O			abduction.
" 5	"	2	O								O					O				adduction from position of abduction.
" 6	1187	2		O				O							O					Internal rotation exceeding 10 deg.
Iliacus 7	"	3		O					O					O						External rotation exceeding 42 deg.
" 8	Model				O				O					O						Flexion preceded by exter. rot of 30 to 40 deg.
" 9	1187	1		O						O							O			Adduction (action so slight.)
Pectineus 10	1186	1	O						O					O						Internal rotation exceeding 20 deg.
" 11	1186 / 1187	3 / 5	O	O	extreme O								O					O		Extreme flexion.
" 12	1186 / 1187	1 / 4	O		O			O							O					Flexion preceded by internal rotation exceeding 20 deg.
" 13	Model				extreme O				O					O						Internal rotation of no. 13 changed as per no 12 by flexion exceeding 90 degs.
Gluteus Maximus 14	1189	1	O					part O	part O											Normal condition.
" 15	"	2	O							part O	part O									" "
" 16			O united	instead	of	divided	action.					all O								" "
" 17	1190	1		O						part O	part O									" "
" 18	"	2		O				part O	part O											" "
" 19	"	3		O								part O	part O							" "
Gluteus Medius 20	1189	1	O					part O	part O											" "
" 21	"	2	O united	instead	of	divided	act-				all O	ion.								" "
" 22	"	3	O	"		"	"	"		"		all O								" "
" 23	1190	1		O						part O	part O									" "
" 24	"	2		O united	instead				all O	of divided	action.									" "
" 25	"	3		O								part O	part O							" "
" 26	1189 / 1190	2 / 1	O	O							all O					part O	part O			Flexion
Gluteus Minimus 27	1189	1	O					part O	part O											Normal condition.
" 28	"	2	O united	instead	of	divided					all O	action.								" "
" 29	"	3	O	"		"	"	"				all O								" "
" 30	1190	1		O						part O	part O									" "
" 31	"	2		O united	instead				all O	of divided	action.									" "
" 32	"	3		O	"		"		"		"		all O							" "
" 33	1189 / 1190	1 / 2	O	O				part O	part O						all O					Flexion.
" 34	1189 / 1190	2 / 1	O	O							all O					part O	part O			"
" 35	1189 / 1190	3 / 3	O	O								all O							all O	"
Quadratus Femoris 36	1191 / 1192	3 / 3	O	O									O					O		"
Obturator Externus 37	1191 / 1192	3 / 3	O	O									O					O		"
" Internus 38	1191	3	O							Neutral									O	Extension.
" " 39	"	3	O							Neutral								O		Flexion.
Pyriformis 40	1191 / 1192	1 / 2	O	O				O							O					"

1191 and 1192. — Geo. R. Thomas Des. Rep.

Would not deviation in the line be produced by muscles in the path of the line of traction?

Would the line of traction be maintained by the

muscle under action forcing aside or compressing muscles in its direct path ?

As all muscles anatomically or functionally related to the one producing the dominant action (except of course the directly opposing ones) must at the same time be undergoing more or less contraction, in performing their office as stays or guys, what effect will

SEE 1196. Completing table of opposing functions of rotators of femur shown on sheet 1196.

Muscle	Drawing.	Figure.	Femur			Knee		Function						Opposing function						Manipulation to demonstrate opposing function.
			Vertical.	Flexed 90 deg.	Strong Flexion.	Flexed.	Not flexed.	Ext. Rotation.	Int. Rotation.	Adduction.	Abduction.	Extension.	Flexion.	Ext. Rotation.	Int. Rotation.	Adduction.	Abduction.	Extension.	Flexion.	
Sartorius 41	1193	1	O				O	O							O					Flexion of knee 90 degs.
" 42	1194	2		O			O	O						Neutral						" " " "
" 43	"	"		O		O		Neutral (nearly)							O					Internal rotation.
" 44	"	"		O		O		Neutral (nearly)						O						External "
Adductor Longus 45	1193 / 1194	3 / 3	O O	O									O					O		Flexion of femur.
" Brevis 46	1193	1	O					O							O					Internal rotation exceeding 25 degs.
" " 47	1193 / 1194	3 / 3	O	O									O					O		Flexion of femur.
" Magnus 48	1193 / 1194	1 / 2	O	O				O							O	Nearly neutral				" " "
" 49	1194	2		O					O					O						External rotation of four degs.
" 50	1193	1	O					Neutral						O						" " " " "
" 51	"	"	O						"						O					Internal " " " "
" 52	1193 / 1194	1 / 2	O	O					"						O					Flexion of femur.
" 53	1194	2		O					O					O						Lowering femur 2 or more inches
Gracilis 54	1193½ / 1195	1 / 2	O	O				O							O					Flexion of femur.
" 55	1193½ / 1195	3 / 3	O	O									O					O		" " "
" 56	1193½ / 1195	3 / 3	O	O		O	O						O					O		" " Knee 90 deg.
" 57	"	2		O			O		O					O						Lowering femur 2 or more inches
Semitendinosus 58	1194½	1	O			O	O	Neutral							O					Internal rotation.
" 59	"	"	O			O	O		"					O						External "
" 60	1194½ / 1195	1 / 2	O	O					"						O					Flexion of femur.
Semimembranosus 61	1194½	1	O					Neutral						O						External rotation of four degrees.
" 62	"	"	O						"						O					Internal " " " "
" 63	"	"		O		O			"					O						External " " " "
" 64	"	"		O		O			"						O					Internal " " " "

1197. Ed. W. Thomas Dec. 1898.

their actions have upon the muscle producing the dominant action ?

What is the limit of contraction of the different muscles ?

What is the relative force exerted with varying degrees of contraction ?

Do not some muscular-tissue bundles perform work equal to or greater than some larger muscular-

tissue bundles owing to receipt of stronger impulses?

Does not the conditions shown by the skeleton differ from those existing in the recent subject or living person sufficiently to change some of the results given?

The thickness of the cartilage upon the acetabular cavity and head of the femur alone might make important changes.

Explanatory of the small amount of matter presented, is the fact that the drawings and model save a great many pages of descriptive matter and appeal to judgment and common sense in a way no amount of descriptive matter could approach.

While it might be said that many of the functions pointed out are but slight in their effects, and for that reason have been omitted by Gray and Morris, still I think they demand recognition in a paper of this character, and I believe I atone for their presentation by showing undoubtedly important functions not mentioned by Gray or Morris.

I believe this line of investigation, crude though it may appear, would be productive of very interesting results if carried on in connection with all the muscles of the body; and would perhaps be rewarded by more than one iconoclastic disclosure. That it would throw much light upon the production, maintenance and reduction of dislocations and fractures is quite obvious.